EPRG-PRCI-APGA
23rd Joint Technical Meeting
Edinburgh, Scotland
6–10 June 2022

INTRODUCING THE APGA ENGINEERING PRACTICE GUIDE: MAINTAINING PIPELINE SAFETY INTO THE FUTURE

PAPER NUMBER: 30

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ABSTRACT

APGA has recently published Public Safety in the Pipeline Industry: An Engineering Practice Guide. The practice guide applies to engineers who work in design and operation of high-pressure energy pipelines and associated facilities, and to those who employ those engineers. One key value of the pipeline engineering profession is that public safety is paramount. The Guide forms part of the pipeline engineering body of knowledge in support of that value. The content aims to support excellence in engineering practice (i.e. how work is done) when it comes to decisions, actions and behaviors that impact public safety.

More than a decade of Australian industry-sponsored research regarding organizational accident prevention has led to many research outputs about how to support the best decision making for public safety and so the Engineering Practice Guide was born.

The development of the content was driven by three principles:

- Experienced people learn best from examples, so the Guide must include many case studies and examples.
- Both individual and organizational action must be addressed.
- The Guide must be as practical as possible.

The guide was launched by APGA in February 2022 and has been well received.

1. INTRODUCTION

The pipeline industry relies on decision making on the part of professional engineers to maintain asset integrity and keep the public safe [1]. Engineering as a profession places great store on technical competence with high standards required for entry to the profession and further requirements in place for continuing professional development and yet not all skills required for excellent decision making sit in the technical realm [2].

Failure of engineered systems does not automatically mean that the engineering was in some way at fault. The history of major disasters shows that causation is rarely grounded in technical ignorance but much more commonly in non-technical aspects [3-6]. Issues such as confusion at organizational interfaces [5], known problems not communicated to decision makers [7] and either clients or contractors cutting corners [8] lie at the heart of major disasters in complex socio-technical systems.

The Australian pipeline sector has an excellent safety record both in occupational safety terms and in protection of the public and environment from harm, and aims to maintain that into the future including through the major transition required to adopt future fuels. As such, an interest in human and organizational factors has been driving the Australian pipeline industry for more than a decade to fund research in this field. The challenge then comes how to communicate the results to the industry at large.

Research has shown that engineers rely on standards, codes and guidelines as a key source of safety information—more so than any other source [9]. With this in mind, APGA in cooperation with their Research and Standards Committee (RSC) has recently published a new guideline titled Public Safety in the Pipeline Industry: An Engineering Practice Guide. This guide is the latest Australian industry initiative to support public safety. Others include research in this area by both the Energy Pipelines and Future Fuels CRCs, the Safety Management Study approach in AS 2885, the Pipeline Engineering Competency System (PECS) and the recently developed website to assist users of our pipeline Standards (AS2885.INFO).

In codes of ethics around the world, professional engineers are obligated to "hold paramount" the safety of the public, but this Guide is not another code of ethics. Instead, it expands upon the obligation and provides guidance for professional engineers and their employers to encourage behaviors which protect both the public and the environment from harm.

The content of the Guide aims to support excellence in engineering practice (i.e. how work is done) when it comes to decisions, actions and behaviors that impact public safety. In particular, it seeks to support pipeline engineers' ability to identify situations that can impact public safety and to analyze how public safety might be impacted, so that the organization and its engineers can respond effectively.

This paper introduces the Guide to an international pipeline audience. The paper starts by describing the origins of the Guide and the theoretical basis of the content before providing an overview of the material covered by the Guide.

2. BACKGROUND

2.1 Origin of the Guide

The Guide has been nearly fifteen years in the making. The desire for additional Australian industry engagement with research into organizational accident prevention was part of the foundations of the Energy Pipelines Cooperative Research Centre (EPCRC) which operated between 2009 and 2018. Ensuring robust impact from research results was a key principle of EPCRC and in general research outputs were written into the suite of Australian Standards for pipelines, AS 2885. The standard covers technical aspects of engineering and so after due consideration it was decided that the non-engineering topics (which are now covered by the Guide) belonged in a separate document that falls under the direct control of the pipeline profession itself. Thus, Future Fuels Cooperative Research Centre (FFCRC) took on the task of writing the Guide and finally the APGA document Public Safety in the Pipeline Industry: An Engineering Practice Guide was born.

The content of the Guide is based on the experience of the authors who between them have many years of living through and thinking about the issues discussed in the Guide. More than that, it draws on more than a decade of research in the field of organizational accident prevention including studies of why accidents happen and studies of why some organizations are successful despite being responsible for complex hazardous technologies.

2.2 Development principles

The Guide deliberately does not read like a research report even though the content is evidence-based. It is well understood that experienced people learn best from cases [10] so the Guide deliberately includes many case studies and examples that are intended to encourage engineers to reflect on their own practice compared to the principles the Guide expounds.

As with much of the social sciences, the safety literature struggles with questions of structure and agency i.e. to what extent is human action driven by broader social circumstances as opposed to the free will of individuals. In the context of safety, this divide is illustrated by programs that focus on behavior modification of individuals and alternatively programs aimed at improving safety culture. In response to this issue, the Guide addresses both individual and organizational action to ensure the best safety outcomes.

The third defining principle in development of the guide is that it must be as practical as possible. Engineers like to know that advice they are being given is grounded in fact, but in the context of decision making for public safety, the focus must be action. The Guide is therefore practically focused with deeper material cited as further reading.

3 ORGANIZING FOR SAFETY

The first part of the Guide covers organizational aspects in two sections as described below.

3.1 Safety oriented culture

Safety oriented culture is all about those in charge motivating and encouraging people to have the right attitude towards safety – not just saying that safety is important, but really embedding that value in the organization.

The first part of organizing for safety addresses a safety oriented culture. This section covers some key ways in which organizations can 'walk the talk'.

3.1.2 Reward the right behaviors

Don't say safety is number one and then have a bonus scheme or give promotions based on financial performance alone. Make sure that all of the right behaviors including good engineering outcomes for public safety and reliability are rewarded.

3.1.3 Focus on outsourced work too

Engineering and construction are most often outsourced, and we must similarly advocate for great safety performance in the way contracts are structured. Give both engineers and contractors an incentive to do the work properly and not cut corners when it comes to safety – remember we're talking long term public safety here, not just safety of workers on site.

It is well established in Australia that relationship contracting can deliver better outcomes with less dispute than other traditional forms of contracting.

3.1.4 Bad news must reach the top

Have an organization structure and management style that means that bad news can get to decision makers. Don't shield them from problems but encourage reporting of engineering concerns by speaking up and raising concerns in a manner which both identifies potential consequences and offers alternative solutions.

3.1.5 The organization must take bad news seriously

Management can only take appropriate corrective action if they know there is a problem.

How an organization responds to news of a problem speaks volumes about their internal safety culture, and high reliability organizations [11] take action on even the smallest indications that all is not well.

A safety oriented culture is a "just culture" [12]. In conducting investigations of failure incidents, instead of leaping to conclusions about who is to blame, a safety oriented management culture actively seeks to understand why the incident occurred, and is willing to implement changes so that the failure is not repeated.

3.1.6 Make time for discussing experiences

Lastly, share lessons learned and encourage older and experienced personnel to tell the stories so that younger personnel can learn. Telling stories about things that have gone wrong in the past and why they happened is an informative and painless means of passing on the knowledge.

Nothing sticks in the mind like reading or hearing about the consequences of not doing the right thing.

Take time for reflection – it's not wasted! Be willing to run an open forum "post mortem" with employees when something has gone wrong, to even better understand how it may have been avoided.

3.2 Safety oriented management

The **Safety Oriented Management** section provides guidance for managing the workplace environment around engineers, supporting them and encouraging good engineering outcomes.

This requires teamwork; and also requires some important matters to be documented in writing.

The AS2885 approach to operations and maintenance of pipelines sets out the obligations for a Pipeline Management System requiring a number of things to be documented in writing, and Engineering Management is really much the same. The expectations for safe and reliable engineering outcomes need to be written down through a structured engineering management system so that they can be clearly communicated to all parties involved.

This guidance is provided in a number of sub-sections:

The sub-section on **pipeline engineering teams** encourages organizations to ensure that the engineering team is given both the time and the resources to properly complete the engineering function, including careful checking of all work done, and modifying the design when required.

Stakeholders are part of the system, and this sub-section points out that there are usually several different parties involved in some way in delivering the engineering, however it is up to the Licensee to ensure that all of the different engineering groups are coordinated and managed effectively.

A written **Engineering policy statement** focused on safety and reliability is more than just an impressive poster on the wall in the design office and a page to include in documents. The real value here is in the team effort required to generate and gain management approval of such a statement in the first place.

The policy statement applies to all of the engineering teams involved, and must align with the other corporate policy statements.

Similarly, preparing a **Management Structure** diagram and a written description of the various engineering responsibilities within that structure forces the team to carefully consider all parties who either contribute to the engineering or influence the engineering outcomes.

The objective of the **Technical Authority** concept is to ensure that the engineering function is both understood and acknowledged at senior management level in the organization. Many years ago, it was common for organizations to have a position known as the *Chief Engineer*, who was both very experienced and very senior in the authority structure of the organization, but that's not common anymore.

The person taking on the Technical Authority role should have:

- Many years of experience in the same sort of work,
- Good interpersonal skills,
- Complete independence from the cost and schedule pressures applicable to the engineering team, and of course
- Senior level authority within management of the organization.

Dealing with commercial pressures can be a challenge. Cost and schedule savings can seem attractive to senior management because they are easily measured and quantified in numerical terms. To help senior management to visualize the extent to which safety and reliability margins may be reduced, engineers should prepare supporting evidence for any concerns. This can include reliability data (frequency and costs of unplanned shutdowns), and failure data (calculated reduction in safety margin, best estimates of remaining fatigue life, etc.). Journal articles documenting experiences of other organizations facing similar scenarios may also assist. Organizations must place first priority on safety, and not on savings, and having a Technical Authority position to represent the engineering function at management level is important in pursuing this objective.

It is most important that any significant concerns arising, and recommendations made about the engineering are written down and communicated clearly, and it is also important that the reasons for management acceptance or rejection of those recommendations are provided in writing as well.

It's not good enough for management to be able to say later on that they were not aware that concerns had been raised by engineers.

The sections on **Competence & Resourcing** say that:

There is no substitute for knowledge and experience, and

Competent and experienced supervision and oversight are critical to any engineering practice.

The Australian pipeline industry has developed a very good system for Pipeline Engineering Competency assessment, which is best utilized when those hiring pipeline engineers insist that only engineers already assessed as competent are acceptable. Organizations must also ensure that experienced engineering leadership is available, either directly, or contracted on an as-needed basis.

It's not good enough to just tell young engineers to copy and paste from another similar document done previously by others for a different project.

Planning & Communication also recommends writing things down clearly so that they can be widely communicated:

A written Engineering Execution Plan should be documented and approved regardless of the size of the job.

Client expectations for the scope, the standard of work and the functionality of the engineering outcomes must be clearly articulated and not subject to misinterpretation.

Finally, no one is perfect, and everybody makes mistakes sometimes. The expectations and requirements for checking and verification of the engineering outputs must be written down in an Engineering Quality Assurance plan so that everyone can be satisfied that mistakes will be found and corrected before the design goes to shop fabrication or field construction.

Regardless of schedule pressures, design rework in the office is much more cost-effective than construction rework in the field.

4 INDIVIDUAL PRACTICE PRINCIPLES

Organizational culture and management systems are important, but ultimately professional engineers make many decisions that can have serious consequences. The Guide therefore includes a section on individual practice principles. Engineering is a collaborative profession. Little engineering work is done by a lone individual. Reflecting that, many of these individual practice principles are about how pipeline engineers can work most effectively for public safety in day-to-day interactions with colleagues, managers, clients and contractors.

For each of the five individual practice principles listed below, the Guide includes a general description of what good practice looks like in this area and a description of why it is important, then there are some 'drawn from real life' examples for discussion about dilemmas linked to this principle and finally a few disaster case studies demonstrating what can happen if engineers get it wrong in this area. The material is designed in this way to give readers plenty of material to draw on for discussion and relate to their own professional practice.

4.1 Talk about public safety

Talking about public safety and, in particular, the consequences of engineering decisions is the first public safety principle. A key factor in making the right choices when doing pipeline engineering work is to make the direct link between many of the tasks done and the real potential for disaster. Especially for work done away from the worksite, it is easy to forget about innocent bystanders and become complacent or even careless. Unless engineers can actively imagine that their work may have consequences, this possibility can quickly fade from attention. Talking about public safety keeps awareness high.

Pipeline engineers should talk openly about the potential public safety impact of their work by taking opportunities to remind themselves and others (including all levels of organizational management and contractors) that decisions have real-world consequences. Taking a step back and talking in plain language about why it's important to get things right can have a direct and positive impact on public safety.

Routinely talking about public safety also makes it easier to take a firm stand when needed.

The Guide includes two workplace situations for discussion and a summary of each of three disaster cases where people knew there were problems but seemed unable to link them to the potentially catastrophic consequences that ultimately resulted. The cases are the Quebec bridge collapse, the Florida International University footbridge collapse and the Enbridge Marshall Michigan pipeline failure.

4.2 Focus on the long term

The next public safety principle is that pipeline engineers must take a long-term view in safety decision making and recognize that failure may occur far in the future as a result of actions taken now. It is easy for the long-term implications of decisions to be lost in the face of pressure to meet short-term goals but pipeline engineers must always consider the interests of those people in the future who can be impacted by engineering decisions, even though they may be separated in time and space from the engineering work itself.

This principle applies in design but equally in operations and maintenance where today's decisions can impact innocent bystanders in decades to come.

The Guide includes four workplace situations for discussion and a summary of the New Orleans hurricane protection system design issues which illustrates the potentially disastrous consequences of not thinking in the longer term.

4.3 Speak up for safety

The next public safety principle is a requirement to speak up for safety.

In some cases, after an accident, it is found that someone knew that a threat existed but for some reason chose not to raise an alarm. Sometimes they tried to speak up and their concerns were ignored but there are also many cases in which people kept their concerns largely to themselves.

Younger engineers may fear that they will be humiliated by raising a silly question. That serves no-one's interests … there are no silly questions when safety is at stake.

Senior members of the profession who work in design are especially obliged to stand up for safety when they decide whether or not to 'sign off' on drawings, reports and specifications at various critical points in a project. This has legal, as well as ethical, implications in some states.

Decisions regarding safety involve risk trade-offs. Should more time and money be expended in order to make additional safety improvements or is the current arrangement safe enough? This principle is not about seeking a perfectly safe system. It's about ensuring that safety considerations are heard and explicitly considered when decisions are made. If you have concerns:

- Articulate them early and often.
- Document them for the attention of your management and request a written response.
- Make a clear link to the specific undesirable outcome that you wish to avoid.
- Draw on evidence of past similar cases to support your argument.
- Propose potential solutions.

Speaking up can be hard, particularly when you know that the news will not be well received, but it is an important part of being a professional engineer to stand up for what you think is the right thing to do. Ultimately, all engineers need to accept that their responsibility and influence have limitations, but no organization sets out to have an accident. Accidents happen because those making important decisions cannot imagine that an accident might happen as a result of their actions. Making that link – reminding the rest of the team and those higher in management of the safety implications of actions – may be all that is needed to change outcomes.

The Guide includes four workplace situations for discussion and a summary of two disaster cases where speaking up for safety was an issue. They are the Ford Pinto failures and the loss of the Challenger Space Shuttle. These two well-known examples clearly illustrate that decision-makers facing schedule pressures were not convinced despite warnings being documented by technical personnel, with tragic consequences.

4.4 Think beyond compliance

The fourth individual practice principle is to think beyond compliance, an objective pursued by high reliability organizations [11] and their employees.

The Australian Standards approach recognizes a requirement to conform to Standards and comply with legislation and regulation. Written rules such as engineering standards, codes of practice, plans and procedures of various kinds represent a form of collective professional knowledge accumulated over many years by many experienced engineers [13]. Knowing which rules apply in a given situation is a key professional competence, but expertise is much more than simple rule following.

Senior engineers in particular have an obligation to understand *why* something is required and so make professional judgments in accordance with the intent of requirements, not just the letter. Sometimes compliance alone is not enough to keep innocent bystanders safe.

The Guide includes three workplace situations for discussion and a summary of two disaster cases where compliance for its own sake was an issue. They are the Enbridge Marshall Michigan pipeline failure and the Texas City refinery fire. These illustrate that simply following the prevailing rules and procedures was not enough to prevent serious negative outcomes.

4.5 Work only within your area of competence

The fifth individual practice principle is working only within your area of competence.

Much of this practice guide is about how pipeline engineers should best exercise their professional judgment. The difficult skill of professional judgement is critical to ensure the best outcomes, but we must never forget that excellent engineering also involves hard technical skills.

Part of working within your area of competence is keeping up to date with developments in your discipline. Another key aspect is having a keen sense of what you know and what you don't know – and sticking to what you know.

The Guide includes five workplace situations for discussion and a summary of the Flixborough chemical plant explosion. Those involved in designing and installing some temporary works were well intentioned in their actions, but neither adequately experienced nor qualified to assess the potential consequences of those works.

5. CONCLUSION

The Guide has a robust pedigree grounded in both industry experience and in depth research but its success will only be proven by its uptake by Australian pipeline engineers and the ongoing excellent public safety record of the industry, particularly through the significant changes to come as we transition to future fuels. It is early days but it has been received well so far.

We are all doing our level best to ensure uptake and implementation of the Guide in the Australian pipeline industry, and we encourage other JTM members to consider the same.

Feedback from others globally is certainly welcome, because in Australia we regularly update such documents with new information, and this is only our first issue of the Engineering Practice Guide.

6. ACKNOWLEDGEMENT

We wish to acknowledge all the authors of the guide: James Czornohalan, Jan Hayes, Susan Jaques, Richard McDonough, Ted Metcalfe, Peter Tuft, and Josh Wickham.

This work is funded by the Future Fuels CRC, supported through the Australian Government's Cooperative Research Centres Program. The cash and in-kind support from the industry, government, and university participants is gratefully acknowledged.

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